

# Competition in the Polish banking market prior to recent crisis for the period 1997–2007 – empirical results obtained with the use of three different models

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# Abstract

The aim of this analysis is to assess the changes in the measures of competition of the Polish banking sector in the period between 1997–2007 (before the financial crisis) with the use of quantitative methods based on the theory of competition measurement in the banking sector (the Industrial Organisation Approach to Banking). In this paper three models have been used for the evaluation of competition: the Panzar and Rosse model (P-R), the Lerner index (LI) and the Boone indicator (BI).

Empirical analysis shows that the degree of competition in the Polish banking market in the period between 1997–2007 followed a slight upward trend. This results are confirmed by the Panzar and Rosse model (P-R), the Lerner index (LI) and the Boone indicator (BI).

The same channels (increase in mergers and acquisitions and deregulation) which had an impact on changes in the competition of banking sectors in the euro zone countries, had an impact on the Polish banking sector due to the involvement of the capital from the euro zone.

**Keywords:** competition, concentration; mergers and acquisitions; market structure, Panzar-Rosse model, Lerner index, Boone indicator

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# 1. Introduction<sup>1</sup>

The aim of this analysis is to assess the changes of competition measures in the Polish banking sector in 1997–2007 (before the financial crisis) with the use of quantitative methods based on the theory of competition measurement in the banking sector (the Industrial Organisation Approach to Banking). The level of competition in the banking sector is important for its stability because it impacts the banks' profitability, the access to external financing and the economic development. The degree of competition in the Polish banking sector was estimated with the use of three models: the Panzar and Rosse (P-R) model, the Lerner index (LI) and the Boone indicator (BI).<sup>2</sup> Also, the changes in the concentration in the Polish banking industry was analyzed by using concentration indices (k bank concentration ratios – CR5 – and the Herfindahl-Hirschman indices – HHI).

Between 1997 and 2007 (before the financial crisis), competition in the Polish banking system was the effect of numerous different determinants, such as globalisation, deregulation, progress in IT technologies, progress in European integration including mergers and acquisitions (M&A) processes, and implementation of the New Capital Accord (Basel II). The main channels: increase in M&A and deregulation which had an impact on the changes in the competition of banking sectors in the euro zone countries, had an impact on the Polish banking sector due to the involvement of the capital from the euro zone. Another important factor which influenced the shape of the banking sector in the analysed period was Poland's accession to the European Union. Due to this fact, the Polish financial law was harmonised with European Union regulations.

Between 1997 and 2001 the process of consolidation was very intensive and was a natural consequence of an increasing number of global mergers caused by the establishment of the euro zone (in 1999). In order to determine the impact of M&A, caused by the establishment of the euro zone (in 1999) on the changes in the level of competition in the Polish banking sector, the Panzar and Rosse (P-R) model and Lerner indices were estimated for the following two sub-periods: (1) in 1997–2001, (2) in 2002–2007.<sup>3</sup>

Empirical analysis shows that the degree of competition in the Polish banking market (before the financial crisis) followed a slight upward trend. The estimation results of the H-statistic and Lerner index for the two sub-periods have shown a slight increase in this measure that was confirmed by a statistical test. Also, values of the Boone indicators for each year show a slight upward trend in competition between period 1997–2007.

The study consists of four parts and a summary. The first part presents the broad scope of the research methods for the measurement of competition. The second part contains an overview of the literature concerning competition measurement in EU banking sectors. The third part describes structural and technological changes in the Polish banking sector in 1997–2007 leading to changes in the competition. The fourth part presents results of the analysis of changes in the degree of competition of the Polish banking sector (based on data from balance sheets and profit and loss

<sup>&</sup>lt;sup>1</sup> The views expressed in this paper are the views of the author and do not necessarily reflect those of the National Bank of Poland.

 $<sup>^{2}\,</sup>$  A detailed description of quantitative methods is presented in chapter 2.

 <sup>&</sup>lt;sup>3</sup> (1) period – with the lower level of average of concentration indices in the banking sector but with increasing trends,
 (2) – period with the higher level of average of concentration but with decreasing trends in 2002–2007. A detailed information about concentration in the Polish banking sector is presented in chapter 4.

accounts of commercial banks) with the use of three models: the Panzar and Rosse model (P-R), the Lerner index (LI) and the Boone indicator (BI). The last part presents a summary of empirical results and conclusions.

## 2. Methods of competition measurement

The competition among banks is a broad concept, covering many aspects of banking environment and behaviour. According to the theory of perfect competition the market sets a price equally acceptable for the borrower and the depositor. This can be achieved through liberalisation of services offered by banks, which consists in removal of any obstacles hampering access to the domestic market of financial services.

Competition in the banking sector is analysed through the market power and effectiveness measure. Research on competition is currently conducted as part of the industrial organisation approach to banking. The literature on the measurement of competition among banks can be divided into two major streams: structural approach developed on the basis of economic theories investigating the Industrial Organisation (IO)<sup>4</sup> and non-structural approach on the basis of the New Empirical Industrial Organisation Theory (NEIO).

The traditional IO theory comprises the following structural models: structure-conductperformance paradigm (SCP) describing the relationship between the market structure, company conduct and the performance, and a theory based on the efficient structure hypothesis (ESH). In structural models, concentration ratios (i.e. Herfindahl-Hirschman, HHI, indices<sup>5</sup> and the k bank concentration ratios,  $CR_k^{\ 6}$ ) are often used to explain competitive performance in the banking industry as the result of market structure (see Bikker 2004). The market structure and entry conditions are usually used as an exogenous variable.

The SCP model developed by Bain (1951) relates structure and conduct to performance. This theory states that in a market with a higher concentration, banks are more likely to show collusive behavior and their oligopoly rents increase performance (profitability). The efficiency structure hypothesis (ESH), developed by Demsetz (1973) and Peltzman (1977) offers a competing explanation of the relation between market structure and performance. This theory states that if banks enjoy a higher degree of efficiency than their competitors, they can: increase shareholder value or gain market share by reducing prices. According to the ESH, concentrated markets are markets where highly effective firms (banks) operate. However, higher profits of firms with high market shares do not result from their power (size) but from higher effectiveness which creates their power. An elaboration on the efficiency hypothesis is the model developed by Boone (2000). Of note, like many other model-based measures, the Boone indicator approach focuses on one important relationship affected by competition, thereby disregarding other aspects (see also Bikker, Bos 2005).

<sup>&</sup>lt;sup>4</sup> In the above theory that deals with market organisation and competition, behaviour of firms is investigated under certain limitations imposed by consumers and competitors. The central issue of this theory was the expansion of the micro-economic analysis with imperfectly competitive markets and the main model discussed in this theory is the oligopoly model. Cf. Łyszkiewicz (2002).

<sup>&</sup>lt;sup>5</sup> The HHI is calculated as the sum of squared market shares of each firm in a market in the terms of assets. It ranges from 0 to 1.

 $<sup>^{6}</sup>$  This index is calculated as market share of the k largest banks in all banking assets.

To assess competitive conditions in a market, the New Empirical Industrial Organization (NEIO) literature provides empirically applicable tests based on either aggregate industry data or individual firm data. These approaches are estimation techniques to identify static models of industry equilibrium which are compatible with the actual data and thereby indicate the type of competitive conduct on the part of the firms/banks. According to NEIO, concentration is an endogenous variable and depends on the behaviours of individual market players that are exogenous from the firm's perspective (Breshnahn 1988). Methods based on NEIO do not take into account the direction of changes in the level of concentration and they presume that the degree of competition does not always depend on concentration measures because other market characteristics, such as dynamic barriers to entry and exit, are more important.

Methods based on NEIO include the Iwata method (1974), Bresnahan (1989) and Lau method (1982), and Panzar-Rosse (1987) model. The Panzar and Rosse provided a measure called the H statistic. However the Panzar and Rosse approach (P-R) has some limitations (Bikker, Spierdijk, Finnie 2007) provided empirical evidence that the level of competition in the banking industry in the existing empirical P-R literature is systematically overestimated). However, despite these limitations, the P-R model has been extensively applied to the banking sector in a number of countries. An alternative indicator of the degree of competition in banking markets based on the NEIO theory is the estimation of the Lerner index (1934), widely used in the specific case of banks on the basis of the Monti-Klein oligopolistic model (Freixas, Rochet 2008).

### 2.1. The Panzar an Rosse model - theoretical framework

Panzar and Rosse (1987) developed a test for competitive market conditions based on the reduced form revenue equation of the firms. The test was based on empirical observation of the impact on firm-level revenues on variations in factor input prices.

This method was derived from a general banking market model,<sup>7</sup> which determines the equilibrium output and the equilibrium number of banks, by maximizing profits at both the bank level and the industry level. This implies, first, that bank *i* maximizes its profits, where marginal revenue equals marginal cost (Bikker 2004):

$$R'_{i}(y_{i}, n, z_{i}) = C'_{i}(y_{i}, w_{i}, t_{i})$$
<sup>(1)</sup>

$$R_{i}^{*}(y, n^{*}, z) = C_{i}^{*}(y, w, t)$$
<sup>(2)</sup>

where:

 $R_i$  – revenue function of bank *i*,

 $C_i$  – cost of bank *i*,

 $y_i$  – output of bank *i*,

n – number of banks,

 $w_i$  – vector of *m* factor input prices of bank *i*,

- $z_i$  vector of exogenous variables that shift the revenue function,
- z vector of exogenous variables that shift the cost function.

<sup>&</sup>lt;sup>7</sup> Cournot oligopoly model with profit maximinization by collusive Cournot oligopolies.

For variables prime (') denotes theirs marginal changes, while asterisk refers to equilibrium value.

Market power is measured by the extent to which a change in factor input prices  $(dw_{ki})$  is reflected in equilibrium revenues  $(dR_i^*)$  earned by bank *i*. In order to identify the nature of the market structure (monopoly or oligopoly, perfect competition or monopolistic competition) the Panzar and Rosse model (P-R) provides a measure called the H statistic.

Panzar and Rosse showed that the sum of the elasticity of the total interest revenues, with respect to changes in banks' input prices  $(w_i)$ , allows inference about the banks' competitive conduct (see equation (3); for more formal specification see: Bikker 2004):<sup>8</sup>

$$\mathbf{H} = \sum_{k=1}^{m} \frac{\partial R_{i}^{*}}{\partial w_{ki}} \cdot \frac{w_{ki}}{R_{i}^{*}}$$
(3)

where:

 $R_i^*$  – revenue function in equilibrium of bank *i*,

 $w_{ki}$  – vector of *m* factor of input prices of bank *i*.

The estimated value of the H statistic ranges between  $-\infty$  and 1. Moreover, Panzar and Rosse (1987) showed that in market equilibrium perfect competition is indicated by the H statistic equal to unity. Due to the fact that under perfect competition, an increase in input prices and thus in average costs should lead to a proportional price increase and (at the firm level) to a proportional rise in revenues. Under monopolistic conditions, an increase in input prices will increase marginal costs, reduce equilibrium output and consequently reduce total revenues and the H statistic is negative or equal to zero. If the market structure is characterised by monopolistic competition, the H statistics will lie between zero and unity – see Table 1 (for more see Bikker 2004).

The first market model the Panzar and Rosse investigated described monopoly (Panzar, Rosse 1987, p. 445–446). Panzar and Rosse proved as well that the H statistic is equal to e - 1 and yields an estimate of Lerner index of monopoly power L = (e - 1)/e = H/(H - 1), where *e* is price elasticity.

Values of H	Competitive environment
$H \leq 0$	Monopoly or perfectly collusive oligopoly
0 < H < 1	Monopolistic competition
H = 1	Perfect competition, natural monopoly in a perfectly contestable market, or sales maximizing firm subject to a break-even constraint

Table 1Interpretation of the Panzar-Rosse H statistic

Source: Hempell (2000, p. 8), Bikker (2004, p. 87).

<sup>8</sup> The above methodology entails various assumptions, which are disused below. Also, for more information see: Gelos, Roldos (2002); Bikker (2004).

The nature of the estimation of the H statistic means that one is especially interested in understanding how interest revenues react to variations in the cost figures. Also, the methodology requires assuming that banks use three inputs (i.e. funds – financial capital, labour, and physical capital), which is consistent with the intermediation approach views that a bank is a firm collecting deposits and other funds in order to transform them into loans and other assets (Sealey, Lindley 1977). The other assumption is that higher input prices are not associated with higher quality services that may generate higher revenues, since such correlation may bias the computed H statistic. Finally, the test must be undertaken on observations that are in a long-run equilibrium.<sup>9</sup> It means that price should equal marginal cost and free entry and exit conditions determine zero economic profit. A value of H < 0 would show non-equilibrium, whereas H = 0 would prove equilibrium (Shaffer 1989).

The Panzar and Rosse approach (P-R) also has some limitations: general limitations consist of the assumptions underlining its use as a measure of competition in banking industry as well as the resulting biases. Generally, the Panzar and Rosse approach was developed on the basis of static (oligopoly) models whereas for dynamic models there are no predictions on the value of H statistic (Corts 1999). Furthermore, Bikker, Spierdijk, Finnie (2007) provided empirical evidence that the level of competition in the banking industry in the existing empirical P-R literature is systematically overestimated. The reason for the misspecifications is that most studies use different definitions of the appropriate variable to represent banks' revenue (different definitions of the dependent variable in the P-R model). This issue will be discussed in detail in the next subsection. However, despite these limitations, the P-R model has been extensively applied to the banking sector in a number of countries.

#### Misspecification in the Panzar and Rosse (P-R) model

Bikker, Spierdijk, Finnie (2007) provided empirical evidence to show that the scaled P-R model is misspecified. The reason for this misspecifaction is that most studies use scaled versions of bank income as the dependent variable in the P-R model and work with revenues divided by total assets. However, scaling changes the nature of the model fundamentally, since it transforms the revenue equation into a price equation. In order to see this fact, we must take into consideration the P-R model proposed by Bikker and Haaf (2002):

$$\ln II = \alpha + a_1 \ln w_l + a_2 \ln w_f + a_3 \ln w_c + \sum_j \beta_j egz_j + \eta \ln(OI/II) + \varepsilon$$
(4)

where:

- ln*II* natural logarithm of interest income,
- $w_l$  the price of personal expenses,
- $w_f$  the price of funds,
- $w_c$  the price of capital,
- egz bank-specific exogenous factors,
- *OI/II* the ratio of other income to total assets.

<sup>&</sup>lt;sup>9</sup> The empirical test for equilibrium is justified on the grounds that competitive capital markets will equalise the risk-adjusted rate of returns across banks to such an extent that equilibrium rates of return should not be statistically correlated with input prices.

*H* is calculated as the sum of the elasticity of a bank's total revenue with respect to the bank's input prices  $(w_l, w_c, w_f)$  and based on equation (4)  $H = a_1 + a_2 + a_3$ . However, equation (4) requires choosing a dependent variable and the value of *H* depends on this choice, although the choice of dependent and explanatory variables may vary.

In addition, the choice between relative and absolute measures of income (total income or interest income) in equation (4) is of crucial importance. Whereas many articles use the natural logarithm of the ratio of income and total assets, others take the natural logarithm of total or interest income. However, the natural logarithm of the ratio of income and total assets is 'the price', as the natural logarithm of interest income is 'the revenue' – the correct dependent variable.

The choice of the dependent variable explains why previous studies find that H-statistic increases with bank size (Bikker, Spierdijk, Finnie, 2006, pp. 17–18). To see this, let us consider equation (4) like as simple panel regression model:

$$y_{it} = \alpha_i + \mathbf{x}_{it}^T \mathbf{\beta} + \varepsilon_{it} \quad i = 1, ..., N \quad t = 1, ..., T$$
(5)

where:

- $\mathbf{x}_{it}$  *it*-th observation on K explanatory variables appearing in equation (4) (all input prices and other bank-specific exogenous factors of bank *i* in time *t*),
- $\beta$  Kx1 vector of coefficients.

Let us denote by  $\hat{\beta}_p$  the OLS estimator of  $\boldsymbol{\beta}$  with  $y_{it} = \ln(H/TA)_{it}$  as the dependent variable and by  $\hat{\beta}_r^{10}$  the OLS estimator with  $y_{it} = \ln(H_{it})$ . It is easy to show that  $\hat{\beta}_p = \hat{\beta}_r + linear$  function of  $\ln(TA_{it})$ . Obviously, H-statistics calculated from  $\hat{\beta}_p$  and  $\hat{\beta}_r$  clearly differ and the 'bias' of  $H_p$  with respect to  $H_r$  is the function of total assets.<sup>11</sup> Bikker, Spierdijk, Finnie (2006) showed that the 'bias' is virtually always nonnegative and must be an increasing function of the total assets. However, an uncalled revenue function generally requires additional information i.e. about market equilibrium, Bikker, Shaffer, Spierdijk (2011).

Another very important issue is the specification of explanatory variables in the P-R model. All inputs are used to generate total income (*TI*), so that:  $\ln(TI) = \ln(II + OI) \approx \ln(II) + OI/II$ , where *II* is interest income and *OI/II* is the ratio of other income (commission and fee income) to interest income. Therefore, in the specification of the model, we should use us the explanatory variable the ratio of other income to interest income variable (*OI/II*), like in equation (4) (see also Pawłowska 2010).

The standard procedure for estimation of the H-statistic involves the application of fixed effects (FE) regression to panel data for individual firms. However, Goddard and Wilson (2009) showed that FE estimator of H-statistic is severely biased towards zero and suggested using GMM estimator for the revenue equation. Also, Goddard and Wilson (2009) showed that dynamic panel estimation eliminates the need for a market equilibrium assumption.

<sup>&</sup>lt;sup>10</sup> Where the subscripts p and r refer to dependent variable in the P-R model, being either 'the price' or 'the revenue'.

<sup>&</sup>lt;sup>11</sup> Note that the H-statistic is the sum of the OLS coefficient of the input prices; i.e.  $H = \beta_1 + \beta_2 + \beta_3$ .

## 2.2. Lerner index

An alternative indicator of the degree of competition in banking markets is the estimation of the Lerner index (1934), widely used in the specific case of banks. The Lerner index is the mark-up of price (average revenue) over marginal cost. The higher the mark-up, the greater the realized market power is. The values of the index range from 0 (perfect competition) to 1 (monopoly). Lerner index never exceeds 1 because marginal cost MC is never negative.

Lerner index measures the monopolist's margin. According to the Lerner index, the market power of a monopolist depends on price elasticity of market demand.

Algebraically, the Lerner index (LI) is presented as equation (6):

$$L = \frac{1}{|e|} = \frac{p - MC}{p} \tag{6}$$

where:

p – price, MC – marginal cost, e – price elasticity of demand.

In the case of perfect competition, price p is equal to marginal cost MC, Lerner index L = 0 (firms under perfect competition have no market power). Positive values of Lerner index L indicate the existence of market power. The higher the value, the greater the market power of a company/ bank and the lower the market competition. In the case of monopoly, Lerner index L = l/e, where e is the value of the price elasticity of demand.

The measurement of Lerner index in the banking industry is based on the Monti-Klein model of oligopolistic competition on the deposit and credit market, pursuant to which the sensitivity of interest rates on deposits and loans to changes in inter-bank rates, regulated by the central bank (Freixas, Rochet 2008) depends on the number of banks. This model examines the behavior of a monopolistic bank faced with a deposit supply curve of positive slope  $D(r_D)$  and a loan demand curve of negative slope  $L(r_L)$ . The bank's decision variables are L (the amount of loans) and D (the amount of deposits), and for simplicity's sake the level of capital is assumed to be given. The bank is assumed to be a price taker in the inter-bank market (r), so that the objective function of profits to be maximised is as follows:

$$\pi(D, L) = (r_L(L) - r) L + (r - r_D(D)) D - C(D, L)$$
(7)

where:

 $r_L$  – interest rate on loans,

L – loan size,

 $r_D$  – interest rate on deposits,

D – deposit size,

r – interest rate on the inter-bank market.

That profit is the sum of intermediation margins on loans and deposit (the net interest income between deposits and loans), minus management costs C(L, D).

The first order conditions with respect to deposits and loans are as follows:

$$\frac{\partial \pi}{\partial L} = \frac{\partial r_L}{\partial L}L + r_L - r - \frac{\partial C}{\partial L} = 0 \rightarrow \frac{\left[r_L^* - r - \frac{\partial C}{\partial L}\right]}{r_L^*} = \frac{1}{\varepsilon_L}$$
(8)

$$\frac{\partial \pi}{\partial D} = -\frac{\partial r_D}{\partial D}D + r - r_D - \frac{\partial C}{\partial D} = 0 \rightarrow \frac{\left[r - r_D^* - \frac{\partial C}{\partial D}\right]}{r_D^*} = \frac{1}{\varepsilon_D}$$
(9)

where  $\varepsilon_D$  i  $\varepsilon_L$  are elasticities for deposits and loans respectively.

These equations are simply the adoption to the banking sector of Lerner Indices (price minus cost divided by price) and inverse elasticities. The Lerner index for expression (8, 9) represents the extent to which the monopolist's market power allows it to fix a price above marginal cost, expressed as proportional to the price. In the case of perfect competition, the value of the index is zero, there being no monopoly power. Starting from this extreme case, the lower the elasticity of demand, the greater the monopoly power to fix a price above the marginal cost. As de Guevara and Maudos (2004) show, relative margins, rather than absolute margins, are the most appropriate for evaluating the evolution of competition, for two reasons. First, oligopoly competition models determine a relation of equilibrium between the relative margin (price minus marginal cost divided by the price) and the structural and competitive conditions of the market. And second, the relative margin offers a proxy for the loss of social welfare that is due to the existence of market power. The extension of the model to the case of an oligopoly (*N* banks) provides the following expression of the first order conditions:

$$\frac{\left[r_{L}^{*}-r-\frac{\partial C}{\partial L}\right]}{r_{L}^{*}}=\frac{1}{N\varepsilon_{L}}$$
(10)

$$\frac{\left[r - r_D^* - \frac{C}{\partial D}\right]}{r_D^*} = \frac{1}{N\varepsilon_D}$$
(11)

which differs from the case of monopoly only in that elasticities are multiplied by the number of competitors (N).

With this simple adaptation, the Monti-Klein model can be reinterpreted as a model of imperfect competition with two extreme cases: monopoly (N = 1) and perfect competition (N = infinity).

### 2.3. Boone indicator

The other alternative indicator of the degree of competition is the Boone model. The Boone method is based on the efficient structure hypothesis (ESH) which assumes that more efficient firms (with

lower marginal costs) have greater market power and thus achieve higher profits. The stronger the competition, the stronger this effect is. In order to support this quite intuitive market characteristic, Boone developed a broad set of theoretical models (see Boone 2000; 2001; 2004). Boone proved that the market shares of more efficient banks (that is, with lower marginal costs *MC*) increase both under regimes of stronger substitution and amid lower entry costs. The above relationship may be expressed by the following equation:

$$\ln s_{it} = \alpha + \beta \ln M C_{it} + u_{it} \tag{12}$$

(4.0)

where:

 $s_{ii}$  – firm's market power defined as the market share of bank *i* in the period *t*,

 $MC_{ii}$  – marginal cost of bank *i* in the period *t*,

 $\beta$  – estimated Boone indicator.

The measure of the degree of competition is the  $\beta$  parameter which takes on values below zero. The higher the degree of competition, the greater the absolute value of negative parameter  $\beta$  specifying the Boone indicator (Leuvensteijn et al. 2007).

# **3. Results of the measurement of competition in European banking sectors** – overview of literature

The importance of competition in the financial sector is the subject of research by bank analysts because the degree of competition in the financial sector may influence the effectiveness of financing and availability of financial services to companies and households and may have an impact on the quality of products. Empirical cross-country investigation in this research area related primarily to the issue of the influence of competition in the financial sector on its stability, the access to external financing and the economic development. Specific to the financial sector is the link between competition and stability (Schaeck, Čihák, Wolfe 2006; Vives 2010). In addition, the relationship between market concentration, market regulation and the level of competition was analyzed.

The establishment of the euro zone also posed a challenge to analysts conducting research on the degree of competition. It was expected that accession to the euro zone would increase competition in the financial sector and exert pressure on banks' profitability, causing an increase in the efficiency of financial institutions (ECB 1999). It was argued that the accession to the euro zone would change the position of the bank being the main financial intermediary, which might cause changes in the financial result and an increase in competitive pressure from the capital market (McCauley, White 1997). In view of these challenges, the banking system of the euro zone countries undertook appropriate strategic precautionary measures to increase the effectiveness by, among others, improving the quality of services, reducing costs and developing alternative sources of income through geographic expansion (ECB 1999). Particularly for banks, the euro adoption increased the volume of cash transactions and reduced profits of foreign exchange transactions. In the area of regulation the euro centralized the system of conducting the monetary policy moving it from the national central banks to the European Central Bank and relaxing the bank entry conditions (Yusov 2004, p. 17). Banks became involved in mergers and acquisitions, in particular cross-border M&A transactions, and entered into strategic alliances.<sup>12</sup> The greatest wave of mergers was recorded just before euro adoption and in subsequent years the pace of consolidation slowed down. However, mergers and acquisitions and the reduction in banking regulations have the largest impact on changes in the competition in the banking sector (Vives 2010). There are several related strands of literature concerning competition in the financial sector. The empirical literature that has investigated the relationships between structural and regulatory factors and performance, access to financing and growth, in the relation to the competition and stability, long recognized in theoretical and empirical research and, most importantly, in the actual conduct of prudential policy towards banks (Vives 2010). Another issue, is the link between competition and concentration (Claessens, Laeven 2004).

A number of analysts, who investigated the trade-off between competition and concentration, found that there is no evidence that banking sector concentration negatively relates to the level of competition, Gelos and Roldos (2002) using the P-R methodology and BankScope data in transition economies (1994–2000), found that banking markets in the Central European countries (including Poland), did not become less competitive, even though concentration increased. In their study, however, the authors pointed to the fact that the process of consolidation, in particular in Central Europe, had not ended yet and therefore it was difficult to make definite conclusions. The above results were confirmed by Yildrim and Philippatoas (2007) and by Claessens and Laeven (2004) in a cross-country research (including Poland). Hempell (2002) reached a similar conclusion with respect to the German banking industry and Coccorese (2004) related to the Italian banking industry. Staikouras and Koutsomanoli-Fillipaki (2006) showed that banks in the new EU countries, among others in Poland, operate under conditions of stronger competition than the old EU countries, due to lower market entry barriers and the presence of foreign capital. Furthermore, Claessens and Laeven (2004) found that the openness of the market determines effective competition especially by allowing (foreign) bank entry and reducing activity restrictions on banks.

A cross-country analysis for Central and Eastern European countries was also conducted by Yildirim and Philippatos 2007) between 1993 and 2000 and by Staikouras and Koutsomanoli-Fillipaki between 1998 and 2002. The results of their analyses indicated there existed monopolistic competition in most analysed banking sectors in Central and Eastern European countries. In addition, Staikouras and Koutsomanoli-Fillipaki (2006) concluded that between 1998 and 2002 only in EU-10 countries, due to lower barriers to entering the market and an increase in the share of foreign capital, the increase in concentration did not cause a decrease in the level of competition in the analysed period.

Different results of research were presented by Bikker, Spierdijk, Finnie (2007) and Bikker and Spierdijk (2008) who were the first to perform a cross-country analysis of changes in competition in 101 countries in the last fifteen years. The authors demonstrated a downward trend in competition in many major economies despite ongoing liberalisation, harmonisation, internationalisation, financial integration and IT developments. They also proved there had been a decrease in competition in banking sectors of Western economies (in particular in euro zone countries) and an increase in competition in Eastern European banking sectors. According to Bikker and

<sup>&</sup>lt;sup>12</sup> In 2005 cross-border transactions accounted for 51% of total M&A transactions – due to the merger of Unicredito and HypoVereinsbank, ABN Amro and Banca Antonveneta as well as Swedbank and Hansabank.

Spierdijk, a slump of the upward trend in competition measures in 2001 and 2002 and their subsequent decrease was caused by a lagged response to the introduction of 'virtual' euro in 1999. However, in the authors' opinion, the introduction of euro caused an increase in competition on the financial market due to, among others, an increase in the competition on the credit market, because it changed the type of services provided by banks and caused a revival on the capital market.<sup>13</sup> Thus, the introduction of euro changed the role of the bank as the so-called financial intermediary which previously was the main provider of financing to companies in euro zone countries.

A number of studies have used the Lerner index to try to determine the trend in competitive behaviour over time. Most studies based on the Lerner index (e.g. Maudos, de Guevara 2004; 2007; de Guevara, Maudos, Perez 2007; Carbó, Rodriguez 2007) found a reduction of competition during the 90s and a higher Lerner index in MU countries. A similar result was found when the analysis was applied on a regional basis within a country (Carbo et al. 2009; Gutierres de Rozas 2007). However, de Guevara, Maudos (2004) demonstrated an increase in competition despite increased concentration (in Germany and the UK) and Angelini and Cetorelli (2003) demonstrated an increase in competition despite an increase in concentration in the Italian banking sector (between 1984 and 1997 the market power decreased). Similarly, de Guevara, Maudos (2004) and de Guevara, Maudos, Perez (2005) demonstrated an increase in competition despite increased concentration (between 1992 and 1999 the market power decreased in Germany and UK), while Fischer and Pfeil (2004) demonstrated an increase in competition in the German banking sector between 1993 and 2001. However, Maudos and de Guevara (2007) demonstrated for 1986–2002 a decrease in the market power in the Spanish banking sector since mid-1990s.

An increase in competition on the credit market in euro zone countries was demonstrated by Leuvensteijn et al. (2007) with the use of the Boone indicator. According to the authors, the increase in competition on the financial market in euro zone countries was caused by, *inter alia*, an increase in competition on the credit market (due to, among others, an increase in corporate bond issuance and a revival on the capital market). The above-mentioned article also pointed to differences in the degree of competition in euro zone countries. Also Schaeck and Čihák (2008) with the use of the Boone indicator confirmed this fact.

Finally, Carbó et al. (2009) found using five measures of competition (the net interest margin (NIM), the Lerner index, the return on assets (ROA), the H-statistic and the HHI market concentration index) that various indicators of competition yield different conclusions on competitive behaviour due to that fact that those competition indicators measure different things.

# 4. Structural and technological changes in the Polish banking sector between 1997 and 2007

The financial system in Poland is mainly based on commercial banks whose share in the assets of the financial sector as a whole is approximately 70%. The role of other financial institutions has been increasing steadily, although it is still low.

<sup>&</sup>lt;sup>13</sup> It should be noted that the establishment of the common currency – the euro was followed by a rapid increase in corporate bond issues: from EUR 30 billion in 1999 to EUR 170 billion three years later (mainly due to an increase in liquidity and an increase in competition in the financial intermediaries sector). See ECB (2007).

The period of 1997–2007 was a period of rapid changes in the Polish banking sector. Banks attempted to devise new development strategies in order to achieve the best financial results. Mergers and acquisitions, enhanced by a fast technological development constituted one of the components of commercial banks' strategy.

When analysing processes that took place in the Polish banking sector between 1997 and 2007 it should be noted that privatisation led to an increase in the share of foreign capital in the Polish banking sector. As of the end of 2007, the share of banks with predominantly foreign capital was approximately 70%, while as of the end of 1997 it was approximately 15%. When analysing ownership transformations in the Polish banking sector in recent years, the stabilisation of the share of foreign capital since 2000 should be emphasised. In 2007, Italian investors, followed by German and Dutch investors played a dominant role in the Polish banking sector (see Figure 6 in Annex A). Due to the fact that foreign capital in banks operating in Poland comes largely from the euro zone countries, the factors that triggered changes in the competition in the banking systems of euro zone countries also had an indirect impact on the Polish banking sector.

In the first half of 1990s, the main consolidation mechanism consisted in acquisitions by strong banks of other banks whose financial condition was poor. Mergers conducted between 1997 and 2001 were a natural consequence of the increasing number of global mergers caused by the establishment of the euro zone (in 1999). Between 2002 and 2007, the pace of consolidation slowed down and since 2004 the main trend has been transformations of banks into branches of credit institutions.

An analysis of the process of mergers and acquisitions between 1997 and 2001 in the Polish banking system allows to distinguish the following types of mergers:

- a merger between a domestic bank and a branch of a foreign bank operating in Poland,

- a merger between two domestic banks having the same foreign investor,

- a merger of banks operating previously in one capital group,

– mergers of banks operating in Poland as a result of a merger of their parent companies outside Poland.

The example of the first type of mergers is, among others, the merger of Citibank (Poland) SA with Bank Handlowy w Warszawie SA, both being entities directly controlled by Citibank Overseas Investment Corp., and the acquisition of ING Bank N.V. Branch in Warsaw by ING Bank Śląski SA owned by ING Bank NV.

The second type of mergers includes the merger of Bank Zachodni SA and Wielkopolski Bank Kredytowy SA, which were subsidiaries of Allied Irish Bank European Investments Ltd.

The third type of mergers includes the acquisition of banks previously operating under one capital group (e.g. acquisition of BIG BANK SA by BIG Bank Gdański SA, merger of Pekao SA Group, i.e. a merger of Bank Polska Kasa Opieki SA with: Powszechny Bank Gospodarczy SA, Pomorski Bank Kredytowy SA and Bank Depozytowo-Kredytowy SA).

The fourth type includes the merger of Bank Własności Pracowniczej with NORDEA Bank Polska as a result of the merger of the Danish Unibank with Swedish, Finnish and Norwegian group Merita Nordbank and the merger of PBK SA with BPH SA triggered by the merger of their owners, i.e. Bank Austria Creditanstalt and HypoVereinsbank, which resulted in the creation of the third largest bank in Poland (Pawłowska 2003). Due to consolidation processes in the Polish banking sector the number of commercial banks has decreased, while the number of bank branches has increased (see Figure 1). The decrease in the number of banks caused by the consolidation has also been observed in euro zone countries (see Figure 2). It should be noted that the number of branches in Poland includes branches of foreign credit institutions (14 in 2007). In 2007 the market share of credit institution branches was 4.3%.

The consolidation in the Polish banking sector (similarly to euro zone countries) led to changes in concentration (measured with the HHI and  $CR_5$  ratios). Changes in concentration in the Polish banking sector measured with the  $CR_5$  ratio and changes in concentration in the Polish banking sector and euro zone countries measured with the HHI index are illustrated in Figure 4 in Annex A. The analysis of the variability of concentration ratios in the Polish banking sector shows that in part of the analysed period (1998–2001) those ratios followed an upward trend (Pawłowska 2005). The increase in concentration ratios was enhanced by mergers and acquisitions conducted by large banks. In turn, between 2002 and 2007 concentration measures were decreasing despite further decrease in the number of commercial banks. The decrease in concentration ratios was caused by a slowdown in the consolidation process and a slower development of large banks (see Figure 3 and 4).<sup>14</sup>

The profitability of commercial banks in Poland between 1997 and 2007 was influenced by a large number of internal and external factors: consolidation and technological processes, real economy, Poland's accession to the European Union. Due to changes in the banks' external environment, between 1997 and 2007 their profitability measured with return on assets (ROA) and return on equity (ROE) also changed. After a significant decrease in the profitability of commercial banks between 2001 and 2003 related to economic slowdown, between 2004 and 2007 a clear improvement in profitability was observed (see Table A2 in Annex A). During the analysed period a downward trend of the net interest margin (NIM) was also observed,<sup>15</sup> but it was still twice as high as the average in EU-25. During the analysed period, the decrease in net interest margin was also caused by a decrease in nominal interest rates resulting from a lower inflation rate. The improvement in banks' profitability was facilitated by, among others, a decrease in the share of non-performing loans<sup>16</sup> in assets, in particular loans granted to companies. An improvement in the quality of the corporate credit portfolio was, on the one hand a result of the so-called balance sheet cleaning (a transfer of some bad loans to off-balance sheet items and the sale of non-performing loans to specialised investment funds). On the other hand, a good economic situation led to high financial results of non-financial companies which consequently contributed to the improvement in the fulfilment of obligations vis-à-vis commercial banks.

The period of 1997–2007 was also a period of the development of electronic technology in banking. Owing to new technical solutions banks were able to improve the quality of their operations, streamline settlement procedures and accelerate cash turnover. In the last decade, technical solutions (including the development of IT technologies and the Internet) became an

 $<sup>^{14}</sup>$  However it should be stressed that the average concentration for the period 1997–2001 was lower than for the period 2002–2007. The average CR5 for 1997–2001 and 2002–2007 amounted to respectively 47.6 and 49.6.

<sup>&</sup>lt;sup>15</sup> Net interest margin is calculated as the quotient of net interest income and average assets in a particular year.

<sup>&</sup>lt;sup>16</sup> It should be noted that since Poland's accession to the EU the classification of non-performing loans changed to a less restrictive classification, for instance for sub-standard receivables from 1 to 3 months into from 3 to 6 months, for doubtful receivables from 3 to 6 months into from 6 to 12 months, for lost receivables from above 6 months to above 12 months. See NBP (2004).

important internal factor enabling banks to improve their management systems and contributed to the development of modern banking products and their distribution channels. It should be stressed that Internet banking was one of the fastest growing commercial applications of the Internet (see Table A3 in Annex A).

An important (possibly the most important) factor which influenced the shape of the banking sector in the analysed period was Poland's accession to the European Union. Owing to this fact, the Polish financial law was harmonised with European Union regulations. It should be noted that as of the date of Poland's accession to EU, one of the entry barriers (Bikker, Bos 2005) for EU banks was removed as a result of introducing a single passport law in Poland.<sup>17</sup>

Another factor driving recent changes in the banking sector has been the introduction of the New Capital Accord (NCA).<sup>18</sup> NCA sets standards for the management of banks for many years by, *inter a lia*, implementing new risk management systems. The aim of the NCA is to improve the quality of risk management in banks, in particular the management of credit risk. A novelty under NCA is the permission to use internal tools for credit risk management under the internal ratings-based approach (IRB). New Capital Accord is binding for credit institutions in the countries which apply recommendations of the Basel Committee for Banking Supervision (among others: EU countries, including Poland). From the legal perspective, NCA was implemented in Poland in 2007, while the possibility to use IRB approach in banks was introduced as of 1 January 2008 (therefore it is not included in the analysed period).<sup>19</sup>

# 5. Analysis of the level of competition of the Polish banking sector between 1997 and 2007 – empirical results with the use of tree different models

## 5.1. Results of competition measurement with the Panzar and Rosse method

In order to estimate the level of competition in the Polish banking sector, a panel study was conducted on annual data from balance sheets and profit and loss accounts of commercial banks for 1997–2007. H statistic for the Polish banking sector (the value of the elasticity of the revenue function) was estimated on the basis of the following equation:

$$IR_{it} = \alpha + a_1 \ln w_{lit} + a_2 \ln w_{pit} + a_3 \ln w_{cit} + \eta \left( OI/II \right)_{it} + \sum_{j=1}^{N} b_j \cdot oth_{it} + \varepsilon_{it}$$
(13)

<sup>&</sup>lt;sup>17</sup> Pursuant to the single passport rule, a credit institution which obtained a banking licence in one EU country may undertake and conduct the activity in the territory of another UE country, without having to undergo another licence procedure. The credit institution is only required to notify the banking supervisor of the host country of its intention to undertake the activity in its territory. See: NBP (2004).

<sup>&</sup>lt;sup>18</sup> The essence of NCA is the so-called three-pillar system which forms an integrated package and is implemented in banks comprehensively: the first pillar concerns minimum capital requirements with greater emphasis on risk, the second pillar concerns the supervisory analysis process and the third pillar is related to market discipline. On 14 July 2004, the European Commission published the Capital Requirement Directive (CRD). On 28 September 2005, the text of CRD was adopted by the European Parliament and after consultations with EU countries in June 2006 two directives were adopted: Directive 2006/48/EC and Directive 2006/49/EC.

<sup>&</sup>lt;sup>19</sup> In Poland, draft legal acts were developed which govern the new manner of risk management in banks on the basis of draft EU directives (directives 2006/48/EC and 2006/49/EC). This concerned a draft amendment to the Banking Law act and drafts of new resolutions of the Commission for Banking Supervision (including Resolution No. 1 to 9 of 13 March 2007).

where:

 $IR_{it}$  - the natural logarithm of interest income  $\ln(II)_{it}$  or the natural logarithm of interest income divided by total assets  $\ln(II/TA)_{it}$  of bank *i* in time *t*.

The price of input is defined as follows:

- $w_{lit}$  the price of labour is the ratio of personnel expenses to total assets of bank *i* in time *t*;
- $w_{pit}$  the price of funds is the ratio of interest expenses to total deposits of bank *i* in time *t*;
- $w_{cit}$  the price of capital is the ratio of other operating and administrative expenses to fixed assets of bank *i* in time *t*.

Other bank specific variables:

- $OI/II_{it}$  other income/interest income of bank *i* in time *t*;<sup>20</sup>
- $\sum_{j=1}^{\infty} oth_{it}$  other bank-specific variables that affect long-run equilibrium bank revenues: the share of loans which are classified as: substandard, doubtful and loss in total assets (*npl*), and the ratio of total deposit to total assets (*dep*), of bank *i* in time *t*;
- $\alpha$  constant term;

 $\varepsilon_{it}$  – error;

 $a_1, a_2, a_3, \eta, b_j$  – regression coefficients.<sup>21</sup>

In order to check the assumptions of the P-R method on a long-run equilibrium in the Polish banking sector, a test was performed by inserting ROA for 1997–2007 in place of the dependent variable in equation (13).<sup>22</sup> Based on the Wald test performed, the hypothesis on a long-run equilibrium in the banking sector at a conventional significance level cannot be rejected, which means that the condition for applying the Panzar and Rosse method is satisfied (results of the above tests are presented in Table B2 in Annex B).

In order to analyse changes in the level of competition in the Polish banking sector the value of H statistic function was calculated for the entire analysed period (1997–2007) and two sub-periods: in 1997–2001 ( $H_1$ ), in 2002–2007 ( $H_2$ ).<sup>23</sup> In order to capture the impact of misspecification, two variants of equation (13) were estimated. The first variant explains the natural logarithm of interest income divided by total assets  $\ln(II/TA)$  as the dependent variable, whereas the second model was based on the natural logarithm of interest income  $\ln(II)$ . Finally, following Delis et al. (2008) and Goddard and Wilson (2009) dynamic panel versions of models (using GMM estimator) for two dependent variables of equation 13 were estimated. The panel data for this analysis comprises all Polish commercial banks for each year (see Figure 1 in Annex A) covered by the National Bank of Poland's balance sheet and income statement. These statistics consist of annual data from all banks reporting to the National Bank of Poland and cover the period from 1997 to 2007.

Values of estimations of H statistics for 1997–2007 for two dependent variables and for three type of estimators (FE,<sup>24</sup> pooled OLS,<sup>25</sup> GMM) are presented in Table 2.

<sup>23</sup> In order to estimate panel analysis coefficients on non-balanced data panel, the STATA 9.2 package was used.

<sup>24</sup> Fixed-effects panel data estimations.

<sup>&</sup>lt;sup>20</sup> With the aim to capture the increasing role of non-interest revenue in banks' income.

<sup>&</sup>lt;sup>21</sup> The sum of regression ratios  $(a_1 + a_2 + a_3)$  determines the value of H statistic for the sector of commercial banks.

<sup>&</sup>lt;sup>22</sup> After replacing the dependent variable with ROA or ROE, the value of H statistic = 0 means that the banking system is in a long-run equilibrium. This test can be easily performed with the use of the above ratios because in the longrun equilibrium profits are equal to zero and both in the case of ROA and ROE they do not depend on input prices.

<sup>&</sup>lt;sup>25</sup> A large part of P-R literature applies pooled OLS estimations (see Bikker, Shaffer, Spierdijk 2011).

Estimations results with time interaction terms for overall sample:		F	Έ	poole	d OLS	GMM		
		ln(II/TA)	ln(II)	ln(II/TA)	ln(II)	ln(II/TA)	ln(II)	
и	1997–2001	$0.55^{1}$	-0.006 <sup>2</sup>	<b>0.49</b> <sup>1</sup>	-0.069 <sup>2</sup>	0.60 <sup>1</sup>	<b>-0.01</b> 4 <sup>2</sup>	
п <sub>1</sub>	p(F-test)	(0.000)	(0.408)	(0.000)	(0.031)	(0.000)	(0.064)	
	2002-2007	0.78 <sup>1</sup>	0.028 <sup>1</sup>	<b>0.78</b> <sup>1</sup>	$0.009^{2}$	<b>0.84</b> <sup>1</sup>	<b>0.011</b> <sup>2</sup>	
п2	p(F-test)	(0.000)	(0.000)	(0.000)	(0.537)	(0.000)	(0.045)	
p(F-test)	$\mathbf{H_0}:\mathbf{H_1}=\mathbf{H_2}$	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Estimatio	ons results for	F	FE		d OLS	GMM		
overall sa	ample:	ln(II/TA)	ln(II)	ln(II/TA)	ln(II)	ln(II/TA)	ln(II)	
ц	1997–2007	0.76 <sup>1</sup>	0.015 <sup>2</sup>	0.73 <sup>1</sup>	0.006 <sup>2</sup>	0.67 <sup>1</sup>	-0.011 <sup>2</sup>	
Н -	p(F-test)	(0.000)	(0.854)	(0.000)	(0.393)	(0.000)	(0.053)	

 Table 2

 Value of H statistic for commercial banks operating in Poland

Note: to test the value of H the Wald tests were used: for monopoly:  $H_0: H \le 0$  versus  $H_1: H > 0$ , and for perfect competition:  $H_0: H = 1$  versus  $H_1: H \ne 1$ .

<sup>1</sup> Hypothesis of  $H \le 0$  and H = 1 was rejected at the significance level of 1%.

 $^2\,$  Hypothesis of  $H \le 0$  was not rejected at the significance level of 1%.

The empirical results with respect to the H-statistic in the period 1997–2007, have shown that the values of H statistic were higher when the dependent variable was scaled by assets (see Bikker, Spierdijk, Finnie 2006, p. 17). By estimating the different regression equations with interaction terms for two periods, significant changes over time were found for the two sub-periods in the overall sample, which was confirmed by the test for significance of the differences between the two periods  $(H_1 = H_2)$  (see Table 2, for detailed see Annex B, Table B3). The empirical results have shown a monopolistic competition as a characteristic of the analyzed banks' behaviour when the dependent variable was scaled by assets ( $\ln(II/TA)$ ), see Table 2.<sup>26</sup> But for the natural logarithm of interest income ( $\ln(II)$ ) as the dependent variable, the results for the whole period and for the subsample covering the period 1997–2001 do not reject the hypothesis of  $H \leq 0$  (corresponding to a neoclassical monopolist or collusive oligopolist) was not rejected. Furthermore, only for the period 2002–2007 and for FE estimator the values of H statistic indicate a monopolistic competition (neither perfect collusion nor perfect competition) for the natural logarithm of interest income ( $\ln(II)$ ). The above results are consistent with Bikker, Spierdijk (2008), Bikker, Shaffer, Spierdijk (2011) for the Polish banking sector, see Table 3.

Results of the panel analysis for the Polish banking sector on the basis of data from the BankScope database obtained by Gelos and Roldos (2002), Staikouras and Koutsomanoli-Fillipaki

<sup>&</sup>lt;sup>26</sup> The values are in the range of above zero and below unity and the Wald tests reveal that H differs significantly from both 0 and 1, and therefore rejects the hypotheses of both monopoly and perfect competition for Polish banking sector at the 1% significance level. The monopolistic competition comprises the features typical of both perfect competition and monopoly, the market is provided with heterogeneous products and, consequently, each company is a monopolist given the product it manufactures, but the companies manufacturing similar products can also be freely accessed.

	Year	Value of H-statistic	Dependent variable	Number of banks	Market structure
Claessens, Laeven (2004)	1994– 2001	0.77 <sup>1</sup>	ln(II/TA)	40	Monopolistic competition
Gelos, Roldos (2002)	1994	$0.54^{1}$	ln(II/TA)	55	Monopolistic competition
Gelos, Roldos (2002)	1999	$0.53^{1}$	ln(II/TA)	55	Monopolistic competition
Yildrim, Philippatoas (2007)	1993–2000	$0.50^{1}$	ln(II/TA)	53	Monopolistic competition
Bikker, Spierdijk (2008)	1992	$0.45^{1}$	ln(II)	50	Monopolistic competition
Bikker, Spierdijk (2008)	2004	0.08	ln(II)	50	-
Bikker, Shaffer, Spierdijk (2011)	4004 0004	0.83	ln(II/TA)	-	-
Bikker, Shaffer, Spierdijk (2011)	1994–2004	-0.19	ln(II)	-	_

## Table 3 Values of the H statistic for the Polish banking sector

 $^{1}$  *H* = 0 and *H* = 1 rejected (level of confidence 99.9%).

Source: Gelos, Roldos (2002, p. 47); Claessens, Laeven (2004, p. 573); Yildrim, Philippatoas (2007, p. 203); Bikker, Spierdijk (2008, p. 26), Bikker, Shaffer, Spierdijk (2011, p. 49).

(2006), Claessens and Laeven (2004), Bikker and Spierdijk (2008), Bikker, Shaffer and Spierdijk (2011) with the use of the P-R method are presented in Table  $3.^{27}$ 

Staikouras and Koutsomanoli-Fillipaki (2006) demonstrated with the P-R method that commercial banks in new European Union countries (EU-10) operate in conditions of a higher competition than countries of the old Union (EU-15) (the H measure when the dependent variable was the ratio of interest income to assets ( $\ln(II/TA)$ ) is higher for EU-10 countries). Sources of higher competition in banking sectors of new EU countries, including Poland, are deemed to be lower barriers to entry into the market and the presence of foreign capital which showed an upward trend in the new EU countries (EU-10) in the analysed period. When analysing the competition in European banking sectors between 1994 and 2004, Bikker and Spierdijk (2008) demonstrated that in 2004 the degree of competition between banking sectors of the 'old' and the 'new' EU levelled off (see Table 4).

Bikker, Spierdijk and Finnie (2007) and Bikker and Spierdijk (2008) demonstrated that in the last period the level of competition in banking sectors of the old European Union countries (both from the euro zone and from outside the euro zone) decreased. The decrease in competition in the analysed countries was caused on the one hand by the creation of very large banks with a large market power and on the other hand by a change in the role of the bank as the main financial intermediary through an increase of the importance of the capital market in corporate financing

<sup>&</sup>lt;sup>27</sup> Only Bikker and Spierdijk (2008) demonstrated a lower level of concentration for the Polish banking sector. It should be noted that the level of competition in the Polish banking industry was measured on the different sample of commercial banks.

Years	Dependent variable	EU-15	EU-10
$1998 - 2002^{1}$	ln(II/TA)	H = 0.54	H = 0.78
$1998 - 2002^{1}$	ln(TI/TA)	H = 0.61	H = 0.46
$1994^{2}$	ln(II)	H = 0.87	H = 0.61
$2004^{2}$	ln(II)	H = 0.55	H = 0.55

Table 4Results of the calculation of the H statistic for EU-15 and EU-10

<sup>1</sup> Staikouras, Koutsomanoli-Fillipaki (2006, p. 39).

<sup>2</sup> Bikker, Spierdijk (2008, p. 26).

and an increase of non-interest income in banks. However, no research results can be found in the literature on the subject of the relationships between the level of competition and an increase in non-interest result in euro zone banks.

Transformations in European banking in recent years resulted from the effect of numerous and different factors (not only the introduction of the single euro currency). Those factors include: globalisation, liberalisation, deregulation, progress in IT technologies, changes in demand for banking services, progress in the European integration, implementation of the FSAP programme and the introduction of the New Capital Accord (Basel II). Therefore, it is difficult to establish unequivocally which of those factors had the strongest impact on competition of financial institutions. In addition, it should be stressed that the results concerning changes in competition in euro zone countries (before the crisis) are ambiguous: on the one hand an increase in competition after the introduction of the single euro currency was detected (see Utrero-González, Callado-Munoz 2007) and on the other hand, the results of Bikker and Spierdijk (2008) indicated a decrease in competition in euro zone countries.

# 5.2. Results of competition measurement on the Polish banking sector with the application of the Lerner index

The calculation of the Lerner index in the Polish banking sector used equation (6) as well as a panel of annual data from balance sheets and profit and loss accounts of Polish banks for 1997–2007, as in the case of the P-R method.

The marginal cost was estimated on the basis of translog cost function (Berger, Mester 1997) with one output (total assets) and three input prices. Symmetry and linear restrictions in input prices are imposed. The cost function was specified as follows (see Fungacova, Weill 2009):

$$\ln TC = \beta_0 + \beta_1 \ln y + 0.5 \beta_2 (\ln y)^2 + \sum_{j=1}^3 \beta_j \ln W_j + \sum_{j=1}^3 \sum_{k=1}^3 \beta_{jk} \ln W_j \ln W_k + \sum_{j=1}^3 \gamma_j \ln y \ln W_j + v_{it} + z_i$$
(14)

where:

*TC* – the firm's total costs including financial costs and operating costs,

y – total assets,

 $W_i$  – input prices estimated in the same way as in the P-R model (see equation (13)),

 $W_1-{\rm the}~{\rm price}~{\rm of}~{\rm labour}~(w_l),$ 

 $W_2$  – the price of capital ( $w_c$ ),

 $W_3-$  the price of funds  $(w_f).$ 

The estimation of the costs function (and hence of the marginal costs) was done for all panel data. Fixed effects are also introduced, in order to capture the influence of variables specific to each firm. Finally, as usual, the estimation is done under the imposition of restrictions of symmetry and of grade one homogeneity in input prices (for details of estimation see Table B4 in Annex B).

Next, the marginal cost (MC) was calculated as a derivative of the cost function against y:

$$MC = \frac{TC}{\mathcal{Y}} \left( \beta_1 + \beta_2 (\ln y_{it}) + \sum_{j=1}^3 \gamma_j \ln W_j \right)$$
(15)

The Lerner index is calculated as the quotient of the difference between the input price and marginal cost to the input price (see equation (6)). The input price in the banking sector is assumed to be interest revenue divided by assets for each bank i in the period t (Angelini, Cetorelli 2003; de Guevara, Maudos, Perez 2007). The calculated values of the Lerner index and the marginal cost for the Polish banking sector are presented in Table 5. Results of the measurement of the marginal cost indicate its decrease between 1997 and 2007.

In order to test the changes in competition between two sub-periods: 1997–2001 and 2002–2007 (with increasing and decreasing concentration), the average values of the Lerner index were

Table 5

Results of the calculation of the Lerner index for each year for the Polish banking sector between 1997 and 2007 (average)

Year	Std. Dev.	Lerner index	Std. Dev.	MC	Number of observations
1997	0.425254	0.3802458	0.09015	0.07307695	83
1998	0.386123	0.3816084	0.08732	0.07155848	81
1999	0.340915	0.2866669	0.09159	0.06980097	73
2000	0.306847	0.4192944	0.08604	0.06887544	72
2001	0.684271	0.3019527	0.08770	0.06913474	70
2002	0.416789	0.0973307	0.08439	0.06642440	67
2003	1.695749	0.1360234	0.08662	0.06589605	59
2004	1.596667	0.1892985	0.08575	0.06461746	59
2005	0.862366	0.2846030	0.08973	0.06457389	58
2006	0.531301	0.2788467	0.08505	0.06336119	59
2007	1.031755	0.2591705	0.08568	0.06254121	60

Table 6

Results of the calculation of the Lerner index for the Polish banking sector for 1997–2001, 2002–2007 and 1997–2007

Years	Lerner index	Std. Dev.
(1) <i>L</i> <sub>1</sub> : 1997–2001	0.3556355	0.0229866
Number of observations		372
(2) $L_2$ : 2002–2007	0.207891	0.0600689
Number of observations		351
$H_0: L_1 = L_2$	p(F-test)	(0.0096)
L: 1997-2007	0.2839089	0.8487746
Number of observations		723

estimated for the following sub-periods:  $L_1$ : in 1997–2001,  $L_2$ : in 2002–2007. The estimated values of the Lerner index for each period are presented in Table 6. The Lerner index is an inverse measure of competition, i.e. a greater Lerner index means lower competition.

The estimation results of the average values of the Lerner index demonstrate a decreasing trend. Between 2002–2007 the level of competition in the entire sector of commercial banks was higher than in 1997–2001, as demonstrated by a decrease in the market power and higher level of competition. Apparently, as confirmed by the test for significance of the differences between the two periods,  $L_1 = L_2$  for all commercial banks.

Results of the estimated Lerner index in the banking sector in Spain, Germany and the Czech Republic are presented in Table 7. It should be noted that in countries with lower concentration measures the Lerner index indicates a lower market power, i.e. higher competition.

Table 7

Values of the estimated Lerner index for selected banking sector	s in EU countries
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V	Spai	in	Germa	any	Czech Republic		
iear	Lerner index	CR <sub>5</sub> (%)	Lerner index	CR <sub>5</sub> (%)	Lerner index	CR <sub>5</sub> (%)	
1997	0.186	45.2	0.17	16.7	-	-	
1998	0.209	44.6	0.16	19.2	-	-	
1999	0.228	51.9	0.17	19.0	0.3076	-	
2000	0.225	54.0	0.14	20.0	0.3111	1	
2001	0.236	53.0	0.12	20.0	0.2912	68.4	
2002	0.249	53.0	-	20.0	0.1703	65.8	
2003	-	43.1	-	21.6	0.4344	65.8	
2004	-	41.9	-	22.1	0.4575	64.0	
2005	_	42.0	-	21.6	0.4209	65.5	

Source: ECB, de Guevara, Maudos, Perez (2007, p. 285); Pruteanu-Podpiera, Weill, Schobert (2007, p. 90), Fischer, Pfeil (2004, p. 319).

# 5.3. Results of competition measurement of the Polish banking sector with the application of the Boone method

In order to measure the level of competition in the Polish banking sector with the Boone method (2000), a panel of annual data from balance sheets and profit and loss accounts of commercial banks for 1997–2007 were used.<sup>28</sup> As the first step to computing the Boone indicator, the marginal cost (MC) was estimated in accordance with equation (14), as in the case of the Lerner index calculation. In the second step, the relation between individual banks' market shares and marginal cost of production was estimated to obtain the Boone indicator as outlined in equation (12). FE, pooled OLS and GMM<sup>29</sup> estimators were used for computing the Boone indicators in the whole panel with interaction variables depicting relationship between the explanatory variables and the time dummies for each year. The value of  $\beta$  coefficients, the Boone indicators, were presented for each year separately (see Table B5 in Annex B).

The values of the Boone indicators calculated for the Polish banking sector based on equation (12) demonstrated a slight upward trend of competition between 1997 and 2007 (see Table B5 in Annex B and Figure 8).

The Boone indicator (2000) was used by Leuvensteijn et al. (2007) to measure the level of competition on the loan market in euro zone countries (Germany, Italy, Spain) and countries from outside the euro zone, e.g. UK (see also Degryse, Kim, Ongena 2009). A comparative analysis showed that the level of competition in the euro zone countries varies (the highest competition on the credit market was identified in Germany and Spain, while in France and Italy it was lower, however it is higher than in the UK, see Figure 7).

## 6. Conclusions

Competition between banks is the crucial issue for the EU countries in general as well as for Poland in particular. This interest is driven by increasing consolidation in the banking sector, changes in production technology and regulation.

The results of the empirical analysis concerning the results of the competition measurement with three different models (the Panzar and Rosse model (P-R), the Lerner index (LI) and the Boone indicator (BI)) demonstrated a slight increase in competition between 1997 and 2007. On the base of tests, a significant difference was found when comparing the competitive behaviour of Polish banks between the two sub-periods (1997–2001 and 2002–2007). It means that the process of consolidation in the Polish banking system which resulted in a slight increase in concentration measures, was not translated into a decline in the degree of competition. It might also mean that the increasing contestability in the Polish banking sector due to the creation of the euro zone and Poland's accession to the EU prevented a decline in competitive pressures. The results of the empirical analysis with the use of a P-R model of the Polish banking sector showed that commercial banks operated under conditions of monopolistic competition only in the period 2002–2007.

<sup>&</sup>lt;sup>28</sup> Data panel included all commercial banks existing in a particular period (1997–2007), like in the case of the Lerner index calculation, as well as the P-R model.

<sup>&</sup>lt;sup>29</sup> A GMM-style estimator was suggested by Schaeck and Čihák (2008).

It should be stressed that the same channels (before the crisis) increase in mergers and acquisitions and deregulation which affected changes in the competition of banking sectors in the euro zone countries. However, the last crisis was a testimony to the failure of the three pillars of the Basel II system. The evidence points out that liberalisation increased banking crises, while strong institutional environment and adequate regulation reduce them. This suggests that coordinating regulation and competition policy is necessary (see: Vives 2010).

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# Annex A

## Figure 1





Source: NBP and Polish Financial Supervision Authority.



# Figure 2 Number of credit institutions in the euro zone (1997–2007)

Source: NBP and Polish Financial Supervision Authority.





Source: NBP and Polish Financial Supervision Authority.







### M. Pawtowska



Figure 5 Share of foreign investors in assets of the Polish banking sector (1997–2007)

Source: NBP and Polish Financial Supervision Authority.

## Figure 6

Share of foreign investors in assets of the Polish banking sector in 2003 and 2007 by country of origin



### Source: NBP and Polish Financial Supervision Authority.





Source: Leuvensteijn et al. (2007, pp. 27-28).

## Figure 8

The Boone indicators for the Polish banking sector for each year (FE, Pooled OLS, GMM)



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Commercial banks	95.5	95.7	95.8	95.8	95.4	95.0	94.8	94.7	94.2	93.8	93.8
1.1. Banks with majority of state ownership	49.3	45.9	23.9	22.9	23.5	25.1	24.4	20.6	20.3	19.8	18.3
1.2. Private sector banks of which:	46.2	49.8	71.8	72.9	71.9	69.9	70.4	73.5	73.1	74.3	75.5
– banks with majority Polish equity	30.9	33.2	24.6	3.4	3.2	2.5	2.6	6.6	4.0	4.6	4.6
– banks with majority foreign equity (with branches of foreign banks)	15.3	16.6	47.2	69.5	68.7	67.4	67.8	66.9	69.1	69.7	70.9
2. Cooperative banks	4.5	4.3	4.2	4.2	4.6	5.0	5.2	5.3	5.8	6.2	6.2

Table A.1 Ownership structure of the Polish banking sector in 1997–2007 (%)

Source: NBP.

### Table A.2

Commercial banking sector's efficiency indicators in Poland 1997-2007 (%)

Efficiency ratios	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Profit before tax over average assets (ROA)	2.1	0.7	0.9	1.1	1.0	0.5	0.5	1.4	1.6	1.8	1.8
Profit before tax over Tier 1 equity (ROE)	37.2	9.2	12.9	14.5	12.8	5.2	5.4	17.1	20.8	23.1	22.9
Net interest margin (NIM) <sup>1</sup>	5.4	4.7	4.0	4.0	3.5	3.3	3.1	3.1	3.2	3.3	3.1
Non-performing loans (NPL) <sup>2</sup>	10.7	10.9	13.2	14.9	17.8	21.1	21.2	14.7	11.5	7.6	5.5

<sup>1</sup> Net interest margin (NIM) = net interest income (interest income minus interest expenses) over average assets.

<sup>2</sup> The share of loans which are classified as: substandard, doubtful and loss, in total assets.

Source: NBP.

## Table A.3 Number of customers with Internet access to bank accounts (in billion)

2004	2006	2007
5.0	9.9	9.8

Source: Polish Bank Association.

Country	Number of CIs in 1995	Number of CIs in 2004	Number of branches in 1995	Number of branches in 2003	Number of M&A 1995–2004	of which cross- -border M&As (%)
Germany	3 785	2 148	48 180	47 351	170	17.8
France	$1\ 469$	897	25 581	25 789	157	21.3
Austria	1 041	796	4 667	4 395	41	29.6
Italy	970	787	23 493	30 502	275	12.2
Netherlands	648	461	6 802	3 671	23	57.7
Spain	506	346	36 465	39 762	95	31.6
Finland	381	363	1 941	1 252	16	25.0
Portugal	233	197	3 4 4 6	5 4 4 0	38	40.0
Luxembourg	220	165	348	269	10	92.9
Belgium	145	104	7 704	4 989	34	30.1
Ireland	56	80	1 043	924	8	62.5
Greece	53	62	2 404	3 300	34	25.7
Euro area	9 507	6 406	162 074	167 644	901	23.2

# Table A.4 Consolidation in the euro area countries

Source: ECB (2005).

# Annex B

#### Panzar and Rosse model

Panzar and Rosse (1977; 1987) introduce a series of tests based on properties of reduced-form revenue equations at the firm level on which the hypothesis of monopoly or oligopoly profit maximization places testable restrictions. Original Panzar and Rosse model for 'monopoly' is presented below (Panzar, Rosse 1987, pp. 445–446):

Let *y* be a vector of decision variables that affect a firm's revenues, so that R = R(y, z), where *z* denotes a vector of variables that are exogenous to the firm and shift the firm's revenue function. The firm's cost function also depends on *y*, so that C = C(y, w, t), where *w* is a vector of factor prices also taken as given by the firm and *t* is a vector of exogenous variables that shift the firm's cost curve.

It follows that the firm's profit function is given by  $\pi = R - C = \pi(y, z, w, t)$ .

Let  $y^0$  be the argument that maximizes this profit function  $y^0 = \max\{R(y, z) - C(y, w, t)\}$ . Also, let  $y^1$  be the output quantity that maximizes  $y^1 = \max\{R(y, z) - C(y, w(1+h), t)\}$  where the scalar h is greater or equal to zero. Also, let  $R^0 = R(y^0, z) \equiv R^*(z, w, t)$  and  $R^1 = R(y^1, z) \equiv R^*(z, (1+h)w, t)$ , where  $R^*$  is the firm's reduced form revenue function.

Then, by definition:

$$R^{1} - C(y^{1}, w(1+h), t) \ge R^{0} - C(y^{0}, w(1+h), t)$$
<sup>(1)</sup>

Using the fact that the cost function is linearly homogeneous in w, this can be written as

$$R^{1} - (1+h) C(y^{1}, w, t) \ge R^{0} - (1+h) C(y^{0}, w, t)$$
(2)

Similarly, it must also be the case that:

$$R^{0} - C(y^{0}, w, t) \ge R^{1} - C(y^{1}, w, t)$$
(3)

Multiplying both sides of (3) by 1+h and adding the result to (2) yields:

$$-h(R^1 - R^0) \ge 0$$
 (4)

Dividing both sides of (4) by  $-h^2$ , we obtain:

$$\frac{R^{1}-R^{0}}{h} = \frac{R^{*}(z, w(1+h), t) - R^{*}(z, w, t)}{h} \le 0$$
(5)

This is a non-parametric result that indicates that a proportional cost increase will result in a decrease of the firm's revenues. Assuming that the reduced form revenue equation is differentiable, taking the limit of (4) for  $h \rightarrow 0$  and dividing by  $R^*$  yields:

$$\frac{\partial R^*}{\partial w_i} \le 0 \tag{6}$$

and finnaly:

$$H \equiv \sum_{k=1}^{m} \frac{\partial R}{\partial w_i} * \frac{w_k}{R^*} \le 0$$
<sup>(7)</sup>

where the  $w_i$  are components of the vector  $w_i$  so that  $w_i$  denotes the price of the  $i_{ih}$  input factor.

Thus we have established that the sum of the factor price elasticities of a monopolist's reduced form revenue equation H must be non-positive. The test statistic H that tries to answer is what is the percentage change in the firm's equilibrium revenue resulting from a one-percent increase in all factor prices. An increase in factor prices shifts up all cost curves, including the marginal cost curve. Consequently, the price charged by the monopolist goes up and the quantity decreases. Since the monopolist operates on the elastic portion of the demand curve, total revenue decreases. Hence, H is non-positive (see: Pawłowska 2010).

Variables	Obs	Mean	Std. Dev.
II	780	493308.4	1092883
II/TA	780	0.11307	0.3838534
OI	780	115808	250697.4
npl	780	0.144561	0.682205
dep	780	0.4098679	0.4582076
w <sub>l</sub>	780	0.023842	0.0301337
$w_p$	723	6.398926	88.97036
w <sub>c</sub>	767	7.65222	121.1115
OI/II	780	0.4861223	2.473912
TC	780	392482.2	863810.4
ROA	780	0.004167	0.2799674
У	780	14.06557	2.020653
<i>Y</i> <sub>2</sub>	780	100.959	27.70162
S	780	0.0140429	0.0297471

Table B.1 Description statistic for the main variables

## Table B.2 Equilibrium test for Polish banking industry (1997–2007)

ROA	Null Hypothesis Summary: Wald test for $H = 0$			
Normalized restriction (= 0)	Value	Probab.		
H-statistic	0.081126	0.2696		

Note: In linear regression on equation (10) a dependent variable has been used ROA. H < 0 is disequilibrium while H = 0 is equilibrium. Equilibrium is confirmed for the Polish banking sector (significant at 1%).

Sample	1997-2001	2002-2007	1997-2007	1997-2001	2002-2007	1997-2007
FE	$\ln(l$	I/TA)	ln(II/TA)	$\ln(II)$		ln(II)
w <sub>l</sub>	0.3385977	0.2973663	0.4699699	-0.0551306	-0.0763515	-0.0439636
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
W <sub>p</sub>	0.1469896	0.4623772	0.3243236	0.0322431	0.0912957	0.0448522
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
w <sub>c</sub>	0.0655363	0.197463	-0.0354428	0.0176917	0.0131127	0.0144976
	(0.011)*	(0.011)*	(0.000)***	(0.000)***	(0.000)***	(0.000)***
OI/II	0.0217714	0.8819037	0.0214903	-0.0102331	0.2448715	-0.004407
	(0.903)	(0.001)	(0.119)	(0.004)	(0.000)***	(0.087)
npl	-0.0379284	-0.0033266	-0.0151498	0.0091651	-0.0050223	0.0044661
	(0.012)	(0.881)	(0.000)***	(0.232)	(0.585)	(0.129)
dep	0.4606447	0.3963901	0.2375799	0.0259846	0.0951231	0.0336342
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
H-statistic	$0.55^{1}$	$0.78^{1}$	$0.76^{1}$	$-0.006^{2}$	$0.028^{2}$	$0.015^{2}$
Housman test	(0.000)		(0.000)	(0.	000)	(0.000)
Number of obs.			7	10		
Number of groups			106			
Sample	1997-2001	2002-2007	1997-2007	1997-2001	2002-2007	1997-2007
OLS	ln( <i>l</i>	TI/TA)	ln(II/TA)	$\ln(II)$		ln(II)
w <sub>l</sub>	0.2429977	0.2132084	0.408431	-0.1164792	-0.0522211	-0.0464906
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
$W_p$	0.1501346	0.5352585	0.2985082	0.0585084	0.1023307	0.0457919
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
w <sub>c</sub>	0.0921373	0.0332863	0.0249312	-0.0105826	-0.0407104	0.0069773
	(0.011)*	(0.011)*	(0.000)***	(0.000)***	(0.000)***	(0.000)***
OI/II	0.1390757	1.493941	0.1612835	-0.0531391	0.2678179	0.002182
	(0 0.000)	(0.001)	(0.119)	(0.004)	(0.000)***	(0.087)
npl	-0.022216	0.0066188	0.0314765	0.0100632	-0.0166045	0.0035321
	(0.000)	(0.527)	(0.000)***	(0.232)	(0.585)	(0.129)
dep	0 1/32135	0 5169243	0.2655795	0.0684027	0.1313395	0.0464149
	0.1452155	0.0100210				
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
H-statistic	$(0.000)^{***}$ $0.49^{1}$	(0.000)*** 0.78 <sup>1</sup>	$(0.000)^{***}$ $0.73^1$	(0.000)*** -0.069 <sup>2</sup>	$(0.000)^{***}$ $0.009^2$	$(0.000)^{***}$ $0.006^2$
H-statistic Housman test (p value)	$(0.000)^{***}$ $0.49^1$ (0.	(0.000)*** 0.78 <sup>1</sup> 000)	(0.000)*** 0.73 <sup>1</sup> (0.000)	(0.000)*** -0.069 <sup>2</sup> (0.	(0.000)*** 0.009 <sup>2</sup> 000)	(0.000)*** 0.006 <sup>2</sup> (0.000)

 Table B.3

 Estimation results of the H-statistic for Polish banking industry (1997–2007)

Sample	1997-2001	2002-2007	1997-2007	1997-2001	2002-2007	1997-2007
GMM	ln(II/TA)		ln(II/TA)	ln(II)		ln(II)
L1.IR	0.11	98289	0.2469129	0.23	40564	0.2192471
	(0.986)	(0.000)***	(0.000)***	(0.002)**	(0.000)***	(0.000)***
w <sub>l</sub>	0.446558	0.276489	0.34732	-0.0414117	0.0020913	-0.0434137
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
$w_p$	0.120238	0.5859286	0.3279865	0.0206041	-0.0558953	0.0316514
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
w <sub>c</sub>	0.0194073	0.0355586	-0.0046261	0.0068127	0.0615963	0.0006159
	(0.011)*	(0.011)*	(0.014)*	(0.000)***	(0.000)***	(0.000)***
OI/II	0.0557849	1.055714	0.0745944	0.0012872	0.1069595	0.0059927
	(0.903)	(0.001)	(0.020)	(0.000)***	(0.000)***	(0.367)
npl	0.007264	-0.0290707	-0.0211732	0.0076215	0.0003042	0.0013953
	(0.012)	(0.000)***	0.020	(0.336)	(0.655)	(0.544)
dep	-0.1374791	-0.5376006	0.3373724	0.0211597	0.001659	0.0234697
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
H-statistic	$0.60^{1}$	$0.84^{1}$	$0.67^{1}$	$-0.014^{2}$	$0.011^{2}$	$-0.011^2$
Saragan test (p value)	(0.000)		(0.000)	(0.000)		(0.000)
Number of obs.	510					
Number of groups	89					

Note: Dependent variable: interest income/total assets is marked as II/A, interest income is marked as II. Unit factor Prote: Dependent variable. Interest income total assess is marked as HA, interest income is marked as H. Our factor prices:  $w_i$  – the price of labour,  $w_p$  – the price of funds,  $w_c$  – the price of capital, p values in brackets, \*significant at 10%; \*\*significant at 5%; \*\*\*significant at 1%. <sup>1</sup> Hypothesis of  $H \le 0$  and H = 1 was rejected at the significance level of 1%.

<sup>2</sup> Hypothesis of H = 0 was not rejected at the significance level of 1%.

Sample	ln( <i>TC</i> )		(p value)
<i>y</i>	1.987421		(0.000)***
$\mathcal{Y}_2$	-0.0979049		(0.000)***
w <sub>l</sub>	0.0787151		(0.000)***
W <sub>p</sub>	-0.0600785		(0.000)***
w <sub>c</sub>	0.0233102		(0.174)
$W_l * W_p$	0.0787151		(0.000)***
$W_p * W_c$	-0.0600785		(0.000)***
$W_c * W_l$	0.0233102		(0.001)***
$y * w_l$	-0.108775		(0.000)***
$y * w_n$	0.052693		(0.000)***
$y * w_c$	-0.0017302		(0.078)***
$W_1 * W_1$	4.500678		(0.000)***
$W_p * W_p$	-0.0199889		(0.000)***
$W_c * W_c$	-0.0284147		(0.078)*
R <sup>2</sup>		0.93	
Number of obs.		710	
Number of groups		106	

Table B.4								
Estimation	results	of the	TC for	Polish	banking	industry	(1997–2	007)

Note: Dependent variable is the natural logarithm of total cost – is marked as  $\ln(TC)$ , the natural logarithm of interest income – is marked as  $\ln(II)$ . The factor prices:  $w_i$  – the price of labour,  $w_p$  – the price of funds,  $w_c$  – the price of capital, p values in brackets, \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%.

### Table B.5

Estimation results of the Boone indicators (1997–2007)

Estimations results with time interaction terms for overall sample for each year	FE		Pooled OLS		GMM		
	β	(p value)	β	(p value)	β	(p value)	
L1.s	-		-		0.215728	(0.000)***	
1997	-1.362251	(0.000)***	-1.703067	$(0.000)^{***}$	-		
1998	-1.385703	(0.000)***	-1.743364	$(0.000)^{***}$	-0.8900554	(0.000)***	
1999	-1.404653	(0.000)***	-1.763236	$(0.000)^{***}$	-0.9001738	(0.000)***	
2000	-1.433257	(0.000)***	-1.791422	$(0.000)^{***}$	-0.9144294	(0.000)***	
2001	-1.433150	(0.000)***	-1.793086	$(0.000)^{***}$	-0.9162538	(0.000)***	
2002	-1.451406	(0.000)***	-1.829626	$(0.000)^{***}$	-0.9245540	(0.000)***	
2003	-1.450362	(0.000)***	-1.829249	$(0.000)^{***}$	-0.9225256	(0.000)***	
2004	-1.447782	(0.000)***	-1.838018	$(0.000)^{***}$	-0.9193144	(0.000)***	
2005	-1.460892	(0.000)***	-1.869365	(0.000)***	-0.9263272	(0.000)***	
2006	-1.484237	(0.000)***	-1.893210	$(0.000)^{***}$	-1.0068180	(0.000)***	
2007	-1.487550	(0.000)***	-1.904658	(0.000)***	-1.0029740	(0.000)***	
$\mathbb{R}^2$	8.0	9	0.87				
Number of obs.	71	0	71	710		511	
Number of groups	106		-		89		